In the matter of an Application
for Letters Pat nt by
Kabushiki Kaisha RICOH
the title of which is:
FLAT THIN TYPE PRISMATIC
BATTERY

DECLARATION

I, Toyonori OGIUE
a citizen of Japan
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do solemnly and sincerely declare that I have a competent knowledge of the English and Japanese languages and that the following is a true and accurate translation of Japanese Laid-Open Patent Publication No. Hei.11(1999)-260320.

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(54) 【Title of the Invention】 FLAT THIN TYPE PRISMATIC BATTERY

(57) 【Summary】

【Subject】 To solve the problems in the prior art and provide a flat thin type prismatic battery whose strength is large and having a high energy density and which can be relatively simply mass-produced.

【Means to solve the subject】 A flat thin type prismatic battery comprising a flat thin type vessel portion having a wide mouth face opened in one direction and which comprises a metal single body having a collar-shaped

portion at the periphery of said wide mouth face and a battery element accommodated between said vessel portion and a cover portion comprising a metal single body and which becomes to be a cover of said vessel portion wherein said collar-shaped portion of said flat thin type vessel portion and said cover portion are airtight-sealed by way of metal joining, characterized in that said battery satisfies the following factors: (1) said battery has a portion formed by bending at least part of said airtight-sealed collar-shaped portion in a direction toward the bottom portion of the vessel portion, and (2) the length of the bent collar portion in the vessel thickness direction from the tip of the bent portion until the wide mouth face is more than 1/2 of the vessel thickness of the vessel portion.

【Claims】

【Claim 1】 A flat thin type prismatic battery comprising a flat thin type vessel portion having a wide mouth face opened in one direction and which comprises a metal single body having a collar-shaped portion at the periphery of said wide mouth face and a battery element accommodated between said vessel portion and a cover portion comprising a metal single body and which becomes to be a cover of said vessel portion wherein said collar-shaped portion of said flat thin type vessel portion and said

cover portion are airtight-sealed by way of metal joining, characterized in that said battery satisfies the following factors: (1) said battery has a portion formed by bending at least part of said airtight-sealed collar-shaped portion in a direction toward the bottom portion of the vessel portion, and (2) the length of the bent collar portion in the vessel thickness direction from the tip of the bent portion until the wide mouth face is more than 1/2 of the vessel thickness of the vessel portion.

【Claim 2】 A flat thin type prismatic battery defined in claim 1, wherein the tip of the bent portion and the bottom portion of the vessel portion are positioned on the same plane.

【Claim 3】 A flat thin type prismatic battery defined in claim 1 or 2, wherein the collar-shaped portion is processed before the tip of the bent-portion and the bottom portion of the vessel portion are processed to have a length so that they position on the same plane.

【Claim 4】 A flat thin type prismatic battery defined in claim 1, 2 or 3, wherein the bent portion has an angle in a range of 70° to 90° to the wide mouth face.

【Claim 5】 A flat thin type prismatic battery defined in claim 1, 2, 3 or 4, wherein the collar-shaped portion is airtight-sealed by means of ultrasonic welding.

【Claim 6】 A flat thin type prismatic battery defined in

claim 1, 2, 3 or 4, wherein the collar-shaped portion is airtight-sealed by means of laser welding.

【Claim 7】 A flat thin type prismatic battery defined in claim 1, 2, 3, 4, 5 or 6, wherein the four edges of the collar-shaped portion are concurrently processed to bend.

【Claim 8】 A flat thin type prismatic battery defined in claim 1, 2, 3, 4, 5 or 6, wherein the collar-shaped portion is processed to bend by means of press-working.

【Detailed Explanation of the Invention】

【0001】

【Field to which the invention pertains】 The present invention relates to a flat thin type prismatic battery.

【0002】

【Prior art】 Along with having made equipments portable, various kinds of new batteries have become necessary to be provided. As a result, nickel hydride batteries, lithium batteries and the like have newly developed. However, there is a strong demand for realization of not only new battery system but also forms thereof. In the conventional batteries, particularly in the batteries in which metal cases are used, a cylindrical form was their standard. This is due to a reason that airtight-sealing is possible and the productivity is excellent. In recent years, prismatic batteries having an exterior shaped in a rectangular parallelepiped form or prismatic batteries whose

components are round d into a r ctangular parallelepiped form have come in practice in order to improve the space efficiency when accommodated in instruments. However, although this method is advantageous in that airtight -sealing can be readily carried out, it is problematic in that the productivity is markedly inferior and the battery cost becomes high. Besides, it is technically very difficult to make into a flat thin type vessel exceeding a certain extent.

【0003】 In view of this, as the method to seal a prismatic battery and which excels in the productivity, discussions were conducted of the sealing by a double-seamering method or a press-working method (a sealing method by way of caulking using a plurality of dies divided to respective portions and linear portion). As a result, these methods were found to have a problem in that it is difficult to perform airtight-sealing. It was also found that they have problems such that being different from the laser welding, a sealed portion is bulged in a collar form to make the armour area to be larger than the internal electrode area and that the armouring processing by means of a heat contraction tube which is used in the conventional cylindrical battery or the prismatic battery sealed by means of laser welding is extremely difficult to be performed. The armouring processing is necessitated in order to prevent the battery

from being corroded, in order to prevent the battery from being short-circuited when it contacts with other battery, or in order to indicate necessary information on the battery.

The flat thin type battery has also a problem in that it is weak against stresses applied from the outside. Such stresses include a stress relating to the bending and a stress due to an impact from the side face direction when the battery is dropped. Separately, when a flat thin type battery is produced, the sealing is performed by a flat type vessel and a cover using a heat-fusing film in many cases. In this case, there are problems such that it is difficult to avoid invasion moisture in a slight amount from the heat-fused portion and because the sealed portion is bulged, the armour area becomes to be larger than the area of the internal electrode.

In order to solve these problems, Japanese Laid-open Patent Publication No. 6(1994)-236750 discloses a technique in that a battery case and a cover member (a metal plate) are airtight-sealed by a coated resin material in accordance with a double-seamering method or a press-working method so that the sealed portion functions as a gasket. However, even in accordance with this technique, it is difficult to completely prevent the moisture invasion.

【0004】

【Subject that the present invention is intended to solve】

The present invention is aimed at solving the foregoing problems in the prior art and providing a flat thin type prismatic battery whose strength is large and having a high energy density and which can be quantitatively produced by a relatively simple manner.

【0005】

【Means to solve the subject】

The present invention solves the above subject by providing a flat thin type prismatic battery comprising a flat thin type vessel portion having a wide mouth face opened in one direction and which comprises a metal single body having a collar-shaped portion at the periphery of said wide mouth face and a battery element accommodated between said vessel portion and a cover portion comprising a metal single body and which becomes to be a cover of said vessel portion wherein said collar-shaped portion of said flat thin type vessel portion and said cover portion are airtight-sealed by way of metal joining, characterized in that said battery satisfies the following factors:

(1) said battery has a portion formed by bending at least part of said airtight-sealed collar-shaped portion in a direction toward the bottom portion of the vessel

portion, and

(2) the length of the bent collar portion in the vessel thickness direction from the tip of the bent portion until the wide mouth face is more than 1/2 of the vessel thickness of the vessel portion.

Here, for the outer surface of the vessel and/or that of the cover, treatment such as coating by a metal or other material than said metal can be applied.

【0006】That is, the conventional flat thin type prismatic battery has a problem in that it is weak against a power when it is physically bent. However, in the flat thin type prismatic battery of the present invention, the bending strength and the resistance to impact from the side face of the battery are markedly improved and because of this, it is not necessary to pay much attention when the battery is handled. In addition, the armouring processing by means of a heat contraction tube, which was problematic in the prior art in that the processing could not be performed as desired because a sealed portion was bulged in a collar form, became possible to be perform by a simple manner. This situation enables to produce a flat thin type prismatic battery having a high energy density.

【0007】In flat thin type prismatic battery of the present invention, by making the tip of the bent portion and the bottom portion of the flat thin type vessel portion such

that they position on th same plane, the armouring processing by means of a heat contraction tube became possible to readily carry out. Particularly, the bending strength and the resistance to impact from the side face of the battery are markedly improved, and this enables to produce a highly reliable flat thin type prismatic battery.

Further, before the bending processing is performed, by using the member whose collar-shaped portion having processed to have a length such that the tip of the bent portion and the bottom portion of the flat thin type vessel portion position substantially on the same plane, it is possible to save the labor in order to cut and complete the length of the tip of the bent portion, where the tact time is remarkably shortened. This reduces the production cost.

Aforesaid "same plane" may be "in plane" which affords such effects as above described or it may be a region of "substantially within the same plane". By making the tip of the bent portion and the bottom portion of the flat thin type vessel portion such that they position substantially on the same plane, the armouring processing by means of a heat contraction tube became possible to readily carry out.

【0008】 In the bending processing, by concurrently subjecting the four sides of the collar-shaped portion to bending processing, it is possible to remarkably shorten

the tact time and to reduce the production cost. In this case, by using the press-working, it is possible to perform precisely controlled processing for the bent collar-shaped portion, where the tact time is remarkably shortened and the production cost is reduced.

It is desired for the bent collar portion to have an angle preferably in a range of 70° to 90° or more preferably in a range of 80° to 90° to the wide mouth face.

In the flat thin type prismatic battery of the present invention, because the bending strength and the resistance to impact from the side face of the battery are markedly improved and because of this, it is not necessary to pay much attention when the battery is handled.

【0009】 In the present invention, by performing the metal joining of the collar-shaped portion by means of ultrasonic welding, it is possible to attain a highly reliable airtight-sealed portion, where the tact time is remarkably shortened and the production cost is reduced. Similarly, by performing the metal joining of the collar-shaped portion by means of laser welding, it is possible to attain a highly reliable airtight-sealed portion, where the tact time is remarkably shortened and the production cost is reduced.

In the following, the present invention will be described in more detail with reference to examples relating to rechargeable lithium batteries. However, the present

invention is not restricted by these examples. Nonaqueous solvents and electrolyte salts which were previously sufficiently purified and controlled to less than 20 ppm with respect their moisture content were used. And members whose oxygen and nitrogen having been removed to battery grade were used. And the fabrication procedures were all conducted in an inert gas atmosphere.

【0010】

【Examples】

Example 1

[CATHODE]

3 parts by weight of polyvinylidene fluoride was dissolved in 38 parts by weight of N-methylpyrrolidone, and 50 parts by weight of $LiCoO_2$ as an active material and 9 parts by weight of graphite as an electrically conductive material were added, followed by being mixed and dispersed in an inert atmosphere by means of a homegenizer to obtain a coating composition for a cathode. The coating composition was applied on the opposite faces of an aluminum foil having a thickness of 20 μm under atmospheric condition by means of a wire bar. The resultant was dried at 125 ℃ for 30 minutes, followed by subjecting to compression molding, to obtain a belt-like cathode 1. The total thickness after the molding was made to be 70 μm for the layer formed on each of the opposite faces.

[ANODE]

2 parts by weight of polyvinylidene fluoride was dissolved in 38 parts by weight of N-methylpyrrolidone, and 40 parts by weight of a product obtained by baking a coke at 2500 ℃ was added, followed by being mixed and dispersed in an inert atmosphere by means of a roll mill to obtain a coating composition for an anode. The coating composition was applied on the opposite faces of an copper foil having a thickness of 20 μm under atmospheric condition. The resultant was dried at 100 ℃ for 15 minutes, followed by subjecting to compression molding, to obtain a belt-like anode 3. The total thickness after the molding was made to be 80 μm for the layer formed on each of the opposite faces.

【0011】The belt-like cathode 1, the belt-like anode 3, and a separator 2 comprising a microporous polypropylene film having a thickness of 25 μm were wound several times in to an elliptical form to obtain an elliptical spiral type electrode body 4 comprising anode 3, separator 2, cathode 1, and separator 2 stacked in this order as shown in FIG.1 (where the separator is not shown in the figure).

The spiral type electrode body 4 thus obtained was accommodated in a flat thin type vessel 5 made of aluminum and whose inside is applied with insulating treatment as shown in FIG. 2. The aluminum-made flat thin type vessel 5 is of a size of 48 mm x 90 mm x 3 mm, and when a collar portion

is included, the size thereof is 58 mm x 100 mm x 3 mm (the thickness of the aluminum plate: 0.2 mm). A cathode lead 6 made of aluminum extending from the cathode collector was spot-welded to a cathode terminal 8 provided at a battery cover 7, and an anode lead 9 made of nickel extending from the anode collector was spot-welded to an anode terminal 10 provided at the battery cover 7. The battery cover 7 is of a size of 58 mm x 100 mm.

This flat thin type vessel 5 was positioned in a vacuum liquid injection apparatus, where a 1.0 mol/l $LiPF_5$ solution dissolved in a mixed solvent comprising ethylene carbonate and dimethyl carbonate at a volume ratio of 1 : 1 was introduced into the vessel under reduced pressure, and thereafter, the cover was superposed on the vessel, and the collar portion 11 at four edges was sealed by means of argon welding. Thereafter, the four corner portions of the collar portion were cut off in a square form while leaving the welded portions of 1 mm, and each of the four edges of the collar portion was bent in a downward direction at an angle of 90°. After this, portions of the collar portion which are projected downward from the battery bottom were cut off, and the entire of the battery excluding the terminal portions was enclosed by a heat contraction tube, whereby a flat thin type prismatic battery having a size of 50 mm x 92 mm x 3 mm of the present invention was obtained.

FIG. 3 is a cross section view of this flat thin type prismatic battery vessel. The length of the bent collar portion in the present invention corresponds to the length indicated by 13, and 12 indicates the vessel width.

For the battery prepared as above described, a capacity thereof and a cycle characteristic thereof when charging and discharging were performed at a current rate of 1/3 C were evaluated. The evaluation of the capacity was conducted on the basis of a battery capacity density per a unit projected area from above and the unit was expressed by mAh/cm^2. The cycle characteristic was evaluated at a time when the initial capacity became to be 80%.

The impact resistance was evaluated in a manner wherein 10 flat thin type prismatic batteries are separately dropped onto the surface of a desk made of quarts from a height of 100 cm so that their side face collides against the desk surface, and the proportion defective occurred is measured. In this case, those whose capacity having been suddenly reduced after the dropping test and those whose performance having become worse due to internal shorts were deemed as being defective. The tact time was evaluated by measuring a time consumed from the step of sealing the collar portion to the step of bending the collar portion in the test plant.

【0012】 Example 2

The procedures of Example 1 were repeated except that the bending treatment of the collar portion was conducted for the four edges at the same time.

【0013】 Example 3

The procedures of Example 1 were repeated except that the vessel whose collar portion having been sealed by argon welding (58 mm x 100 mm x 3 mm) was set to a die having a bending R of 0.5 provided in a press machine and the upper punch was descended, where the bending processing was performed for the four edges of the collar portion at the same time at a punch load of 150 Kgf.

【0014】 Example 4

The procedures of Example 3 were repeated except that prior to performing the bending processing, the battery cover and the collar portion were previously subjected to die-cutting processing as shown in FIG. 4 to have a length so that the tip of the bending processed portion and the bottom portion of the flat thin type vessel portion are positioned substantially on the same plane.

【0015】 Example 5

The procedures of Example 4 were repeated except that the four edges of the collar portion were welded by means of ultrasonic welding. The ultrasonic welding was performed using a head having a welding area of 20 mm x 3 mm, where the welding was performed for the entire periphery of the collar

portion while shifting the head so as to have an overlap of 2 mm. The ultrasonic welding was performed using a batch type welder of 20 KHz and under conditions of 20 μm for the amplitude, 15 Kgf for the pressure, and 0.2 sec/shot for the welding time.

【0016】 Example 6

The procedures of Example 4 were repeated except that the four edges of the collar portion were welded by means of YAG laser welding. The YAG laser was irradiated along the center of the joined portion of the collar portion. The welding was performed under conditions of 370 V, 1.7 ms and 150 pps for the pulse and 20 mm/s for the scanning speed.

【0017】 Comparative Example 1

The procedures of Example 1 were repeated except that the bending processing was not performed.

【0018】 Comparative Example 2

The procedures of Example 1 were repeated except that the four edges of the collar portion were fused by means of a heat-fusing film made of polypropylene.

【0019】

【Table 1】

Example	1	2	3	4	5	6
capacity density per unit projected area (mAh/cm^2)	13.0	13.0	13.0	13.0	13.0	13.0
cycle characteristic (cycle number)	200<	200<	200<	200<	200<	200<
proportion defective to impact from side face (%)	20	20	20	20	20	20
tact time (second)	80	65	62	48	33	33

【0020】

【Table 2】

Comparative Example	1	2
capacity density per unit projected area (mAh/cm^2)	10.9	13.0
cycle characteristic (cycle number)	200<	132
proportion defective to impact from side face (%)	80	50
tact time (second)	30	90

【0021】 FIG. 5 is a graph showing the relationship between the length of the bent collar portion bent at an angle of 90° to the wide mouth face and the bending load. In the experiment, the battery was fixed to a pedestal such that the central portion of the battery in the longitudinal

direction came to situate at a right-angled end portion of the pedestal, and a prescribed load was separately applied to an end portion of the non-fixed side of the battery from above in a downward direction, where a maximum load required for being bent until the angle of 30 ° was recorded.

【0022】 FIG. 6 is a graph showing the relationship between the angle of the bent collar portion to the wide mouth face and the bending load. In the experiment, the battery was fixed to a pedestal such that the central portion of the battery in the longitudinal direction came to situate at a right-angled end portion of the pedestal, and a prescribed load was separately applied to an end portion of the non-fixed side of the battery from above in a downward direction, where a maximum load required for being bent until the angle of 30 ° was recorded.

【0023】 FIG. 7 is a graph showing the relationship between the angle of the bent collar portion to the wide mouth face and the proportion defective in the impact resistance test from the side face. In the impact resistance test, 10 flat thin type prismatic batteries were separately dropped onto the surface of a desk made of quarts from a height of 100 cm so that their side face collides against the desk surface, and the proportion defective occurred is measured. In this case, those whose capacity having been suddenly reduced after the dropping test and those whose performance

having become worse due to internal shorts were deemed as being defective.

【0024】

【Effects】 1. Claim 1

The bending strength and the impact resistance from the battery side face are remarkably improved. Thus, it is not necessary to pay much attention also when the battery is handled. The armouring processing by means of a heat contraction tube that is difficult to be performed as desired in the prior art because a sealed portion is bulged in a collar form can be readily performed. This enables to produce a flat thin type prismatic battery having a high energy density.

2. Claim 2

The armouring processing by means of a heat contraction tube can be readily performed. The bending strength and the impact resistance from the battery side face are remarkably improved. Thus, it is not necessary to pay much attention also when the battery is handled.

3. Claim 3

It is possible to save the labor in order to cut and complete the length of the tip of the bent portion, and the tact time is remarkably shortened. This reduces the production cost.

4. Claim 4

The bending strength and the impact r sistance from the battery side face are remarkably improved. Thus, it is not necessary to pay much attention also when the battery is handled.

5. Claims 5 and 6

It is possible that a highly reliable airtight-sealed portion is attained, the tact time is remarkably shortened, and the production cost is reduced.

【Brief Description of the Drawings】

FIG. 1 is a view illustrating an elliptical spiral type electrode body.

FIG. 2 is a view illustrating an embodiment in that a cathode lead made of aluminum and an anode lead made of nickel are welded to a flat thin type vessel made of aluminum and a battery cover.

FIG. 3 is a view illustrating a cross election of a battery vessel after the bending processing.

FIG. 4 is a view illustrating an embodiment of die-cutting processing for the four edges of a battery cover or a battery vessel.

FIG. 5 is a graph showing the relationship between the length of the bent collar portion and the bending load.

FIG. 6 is a graph showing the relationship between the angle of the bent collar portion to the wide

mouth face and the bending load.

FIG. 7 is a graph showing the relationship between the angle of the bent collar portion to the wide mouth face and the proportion defective in the impact resistance test from the side face.

【Explanation of reference numerals】

1 belt-like cathode

2 separator

3 belt-like anode

4 spiral type electrode body

5 flat thin type vessel whose inside is applied with insulating treatment

6 cathode lead made of aluminum

7 battery cover

8 cathode terminal

9 anode lead made of nickel

10 anode terminal

11 collar portion

12 vessel thickness

13 length of bent collar portion

FIG. 1

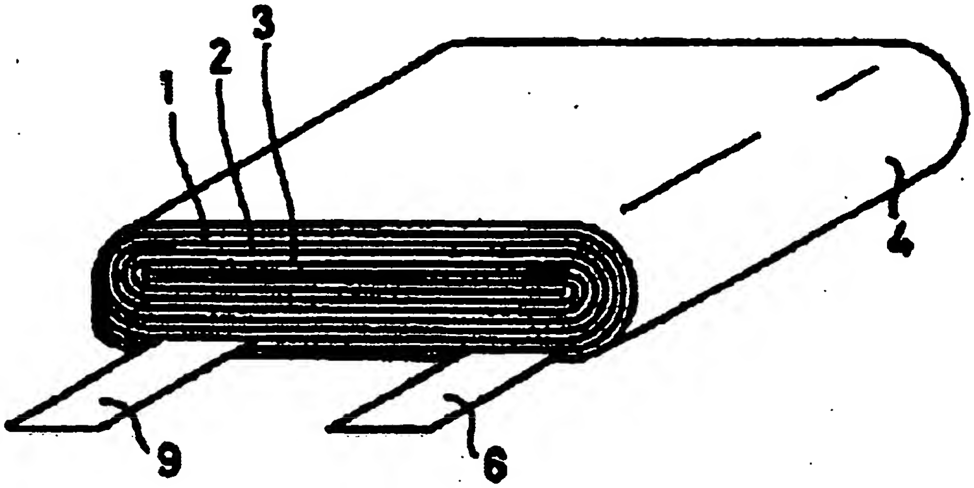


FIG. 2

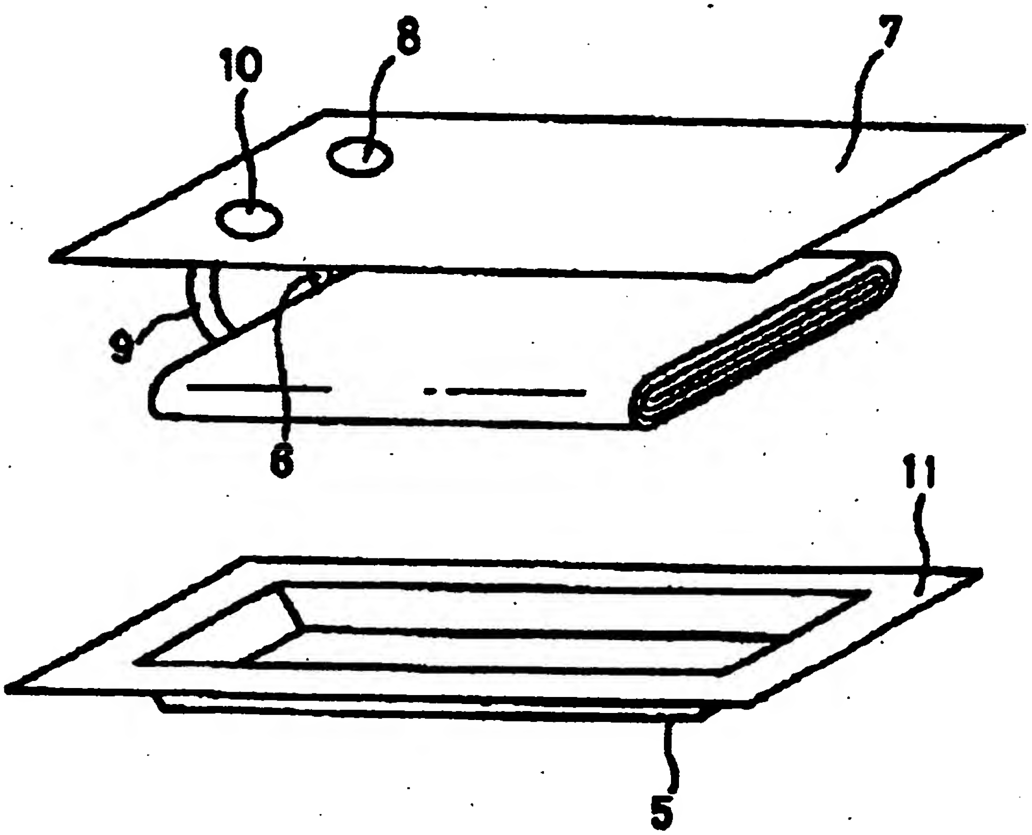


FIG. 3

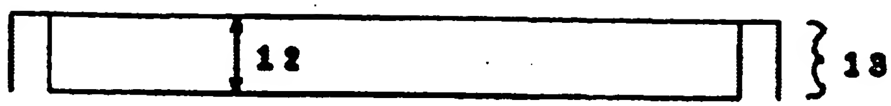


FIG. 4

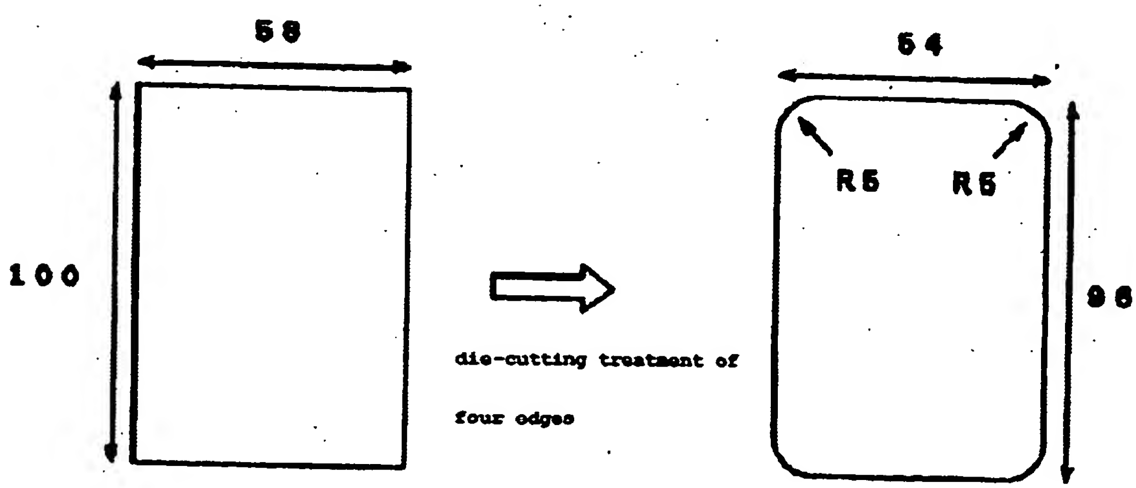


FIG. 5

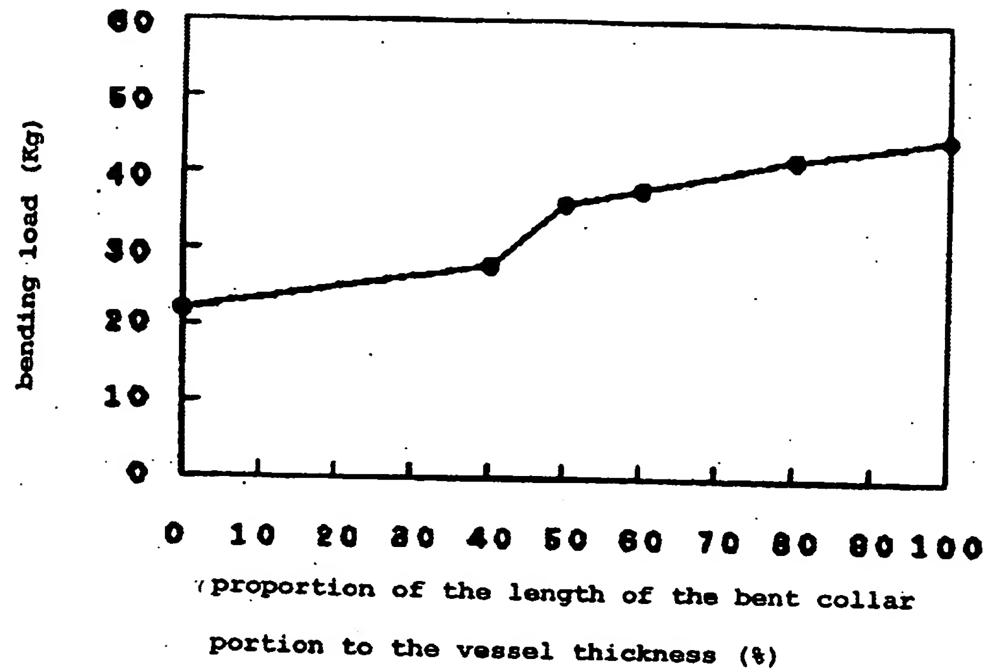

60
50
40
30
20
10
0
bending load (Kg)
0 10 20 30 40 50 60 70 80 90 100
proportion of the length of the bent collar
portion to the vessel thickness (%)

FIG. 6

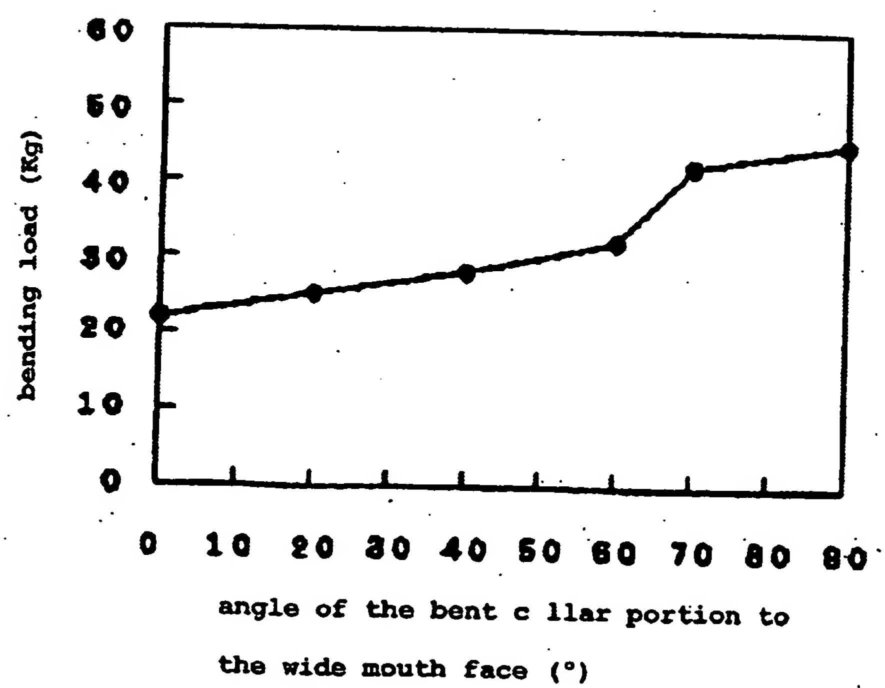
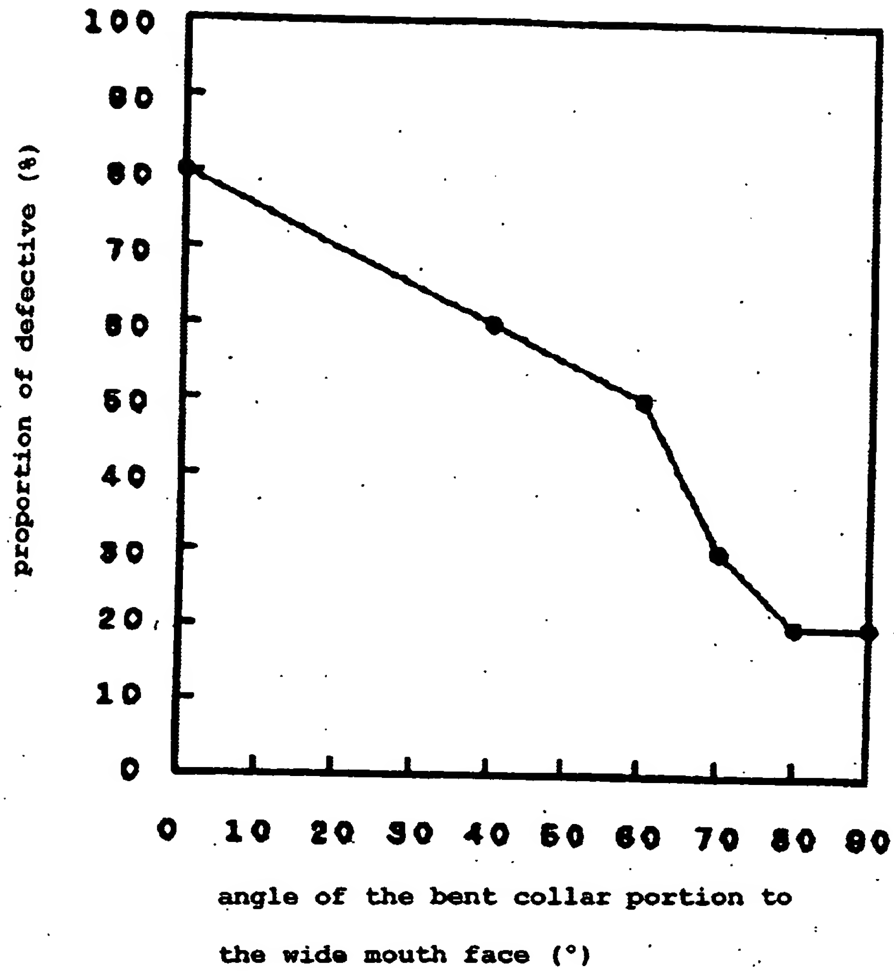

60
50
40
30
20
10
0
bending load (Kg)
0 10 20 30 40 50 60 70 80 90
angle of the bent c llar portion to
the wide mouth face (°)

FIG. 7



100
90
80
70
60
50
40
30
20
10
0
proportion of defective (%)
0
10
20
30
40
50
60
70
80
90
angle of the bent collar portion to
the wide mouth face (°)